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The Annealing of Commercial Glassware

By F. W. Noel

ALTHOUGH it may with truth be said that the main problem of annealing commercial glassware was solved with the advent, some few years ago, of the modern type of lehr, yet many annealing difficulties are still encountered which can only be overcome by a thorough knowledge of the principles underlying the process of annealing glass.

Of even greater importance is the fact that most manufacturers are still under the impression that "well-annealed," in the generally accepted sense of "absence of stress," is the best condition for the finished article from the point of view of ultimate behavior.

There has been much valuable work done on the subject of annealing and strength of ware during the last few years, but the busy manufacturer has time only for a cursory examination of the facts and certainly no time to review the whole material and to condense it into a form for handy reference. Realizing that something of the sort was necessary, however, the writer has made an attempt to summarize the work carried out on the annealing of glass where it is of direct practical value to the glass manufacturer.

Stresses in Glass

Before the main subject can be discussed it will be necessary to call to mind one or two fundamental facts concerning the characteristics of glass during heating or cooling. Let us consider what happens when a slab of glass, free from stress, and at a uniform temperature, say, of 250° C., is cooled in air. The outer surface naturally cools first and has a tendency to contract. The inner layers or core of the slab, however, are still at the initial temperature and resist the tendency of the outer surface to contract. Stresses are therefore set up across the section of the slab, the outer surface, where there is the tendency to occupy a smaller volume, being in tension while the inner core will be in a state of thrust. We have, then, the fact that when a slab of glass at 250° C. is cooled in air, the stresses established are tension at the outer surface and compression in the inner layers. Now, assume that the outer surface of the slab has reached atmospheric temperature. As the same temperature gradient exists across the section of the slab, the same stresses exist as before, but when the inner layers of the slab gradually assume atmospheric temperature the stresses disappear in proportion. Finally, when the temperature is uniform across the section of the slab, the stresses will have disappeared entirely. Stresses which are the outcome of a temperature gradient across the section of a glass sample and which disappear entirely with the temperature gradient, are termed temporary stresses.

It is, however, a generally accepted fact that when a glass article hot from the mould has been cooled rapidly either exposed or by a controlled process such as in a lehr or muffle, the outer surface is found to be in compression and the inner surface in tension. Consider, for example, de la Bastie's process of plunging hot glass into oil at 200°-300° C. in order to establish intense external compression, and so toughen the article.

What explanation can be offered, then, to account for the foregoing facts; first, that a glass article cooled from a temperature of 250° C. acquires *tensile* stress on the outer surface so long as the temperature gradient exists and secondly, that a glass article when rapidly cooled from a semi-molten condition acquires a permanent *compressive* stress on the outer surface. Although the two statements appear contradictory, yet the explanation is very simple. Let us consider what happens when glass is cooled from a semi-molten condition to ordinary temperatures. The outer surface being exposed, cools more quickly than the internal layers and will therefore reach a "set" condition first. By a "set" condition, of course, is meant a condition where the glass is to all intents and purposes a solid, with the characteristics of a solid. Upon further contraction of the outer rigid surface, the inner layers of glass, which are still mobile, yield or adjust themselves to this contraction. Any stresses that are set up, therefore, exist momentarily, at once being relieved by the yielding or flow of the inner layers. When the inner layers in their turn, "set" and assume properties characteristic of "solid" glass, there is an absence of stress in the glass only so long as the original temperature gradient does not change. When the outer surface reaches ordinary temperatures and the inner layers are still at a higher temperature, their tendency to contract due to further cooling

is prevented, or partially prevented, by the outer surface, and stresses are then established. As there exists a tendency for the inner layers to occupy a smaller volume, then the stresses are internal tension balanced by thrust or compression on the outer surface.*

It is apparent from the foregoing that if there exists a large temperature gradient across the section of the glass during the period in the cooling process when the glass definitely begins to assume the solid condition, then, when the glass acquires temperature uniformity at ordinary temperatures, the stresses set up will be large; and on the other hand, if the initial temperature gradient is small, the final stresses will also be small.

Obviously then, apart from such considerations as coefficient of expansion, conductivity, and other physical characteristics, the final stresses in glass after the cooling process is complete are dependent upon the rate at which the glass "sets," or rate of change of viscosity, and also upon the initial temperature gradient across the section of the glass during the period of "setting."

Viscosity

By viscosity is meant a disinclination of the glass to flow. One speaks of pitch as being a highly viscous liquid, for the disinclination to flow is such that if a piece of pitch were placed in a funnel, at ordinary temperatures it would take a considerable number of days to flow through the stem. If the temperature of the pitch were increased, however, the inclination to flow would also increase, until, if the temperature were raised sufficiently, the pitch would flow through the funnel in a matter of seconds. The pitch changes without discontinuity† on increase in temperature from a rigid "solid" to a thin liquid.

Glass behaves in a similar manner, changing when cooled through a certain range of temperature from a thin liquid to a rigid "solid." Now this continuous "solidification" of a single phase occurs at different rates for different glasses and moreover the range of temperature through which the "solidification" occurs varies with the composition of the glass.

The rate of change of viscosity has been investigated by many observers, Twyman[1] being the first to realize that the viscosity or change of viscosity with temperature, was the most important factor in the problem of annealing glass. Twyman's investigations led him to the conclusion that the change of viscosity with temperature was such that for every 8° C. fall in temperature, the viscosity or disinclination to flow, was doubled. The method of investigation was a simple one, observations being made of the rate of fall at varying temperatures of a strip of glass loaded with a known weight.

Later, other observers obtained results which varied slightly from Twyman's value of 8° C. for the range of temperature over which viscosity was doubled. Tool and Valasek[2] gave the range as from 7° C. to 9° C., while Adams and Williamson[3] gave 8° C. to 11° C. At Sheffield, English[4] examined the rate of change of viscosity of a large number of glasses and confirmed Adams and Williamson's values of 8° C. to 11° C.

The Annealing Temperature of Glass

It is apparent from a consideration of the rate of change of viscosity with temperature that to anneal glass correctly, the temperature gradient across the section of the glass must be small at those temperatures where the glass enters the "solidification" range, after which the temperature gradient may be progressively increased as the viscosity becomes proportionately greater. It is necessary, then, to decide upon a temperature where the glass enters the "solidification" range and this temperature is invariably referred to as the annealing temperature. Although it is obvious that the annealing temperature is quite arbitrary, it has been customary to regard it as the temperature at which the viscous yielding of the glass is sufficient to relieve all but 4% or 5% of the existing stresses in the glass in two or three minutes.

The annealing temperature, of course, has to be determined definitely for each particular glass. Attempts have been made to assign values to the constituent oxides and to calculate the annealing temperature from the percentage composition of the glass, but it cannot be said that this method of arriving at the annealing temperature is a very satisfactory one.

There are several methods employed to determine the annealing temperature of glass. English and Turner[5] used an optical method based on the viscosity of glass, while Peters and Cragoe[6] and Tool and Valasek[7] determined the annealing temperature from characteristic properties of glass other than viscosity. Twyman[8] used the apparatus referred to earlier, for determining the viscosity. That fairly close agreement is obtained is shown from Table I, where the results of three methods on the same series of glasses are compared.

TABLE I

Description of Glass	Upper and Lower Limits in Annealing Range					
	Heat Absorption		Optical Method		Expansion Method	
Barium Flint	520° C	560° C	515° C	550° C	510° C	580° C
Light Crown	495°	525°	480°	530°	480°	530°
Borosilicate Crown.	515°	565°	525°	550°	525°	590°
Light Barium Crown	575°	605°	570°	610°	565°	620°
Medium Flint	455°	485°	460°	510°	440°	500°
Light Flint	485°	525°	485°	510°	475°	540°

Bureau of Standards Scientific Paper No. 393.

The annealing temperature varies very widely for glasses of different composition, falling between 500° and 600° C. for most commercial glasses. This does not include the lead crystal glasses, which generally have an annealing temperature below 500° C. Table II shows the variation of the annealing temperature with composition.

*We print this without compunction or apology in spite of Dr. Berger's recent papers.—F. W. P.

†We refer our readers to Dr. Sullivan's paper in this journal (November, 1931) for a consideration as to whether there is discontinuity or not.—F. W. P.

[1] J. Soc. Glass Tech., 1, 61-73 (1917).

[2] Tool and Valasek, Trans. Am. Inst. Min. Met., Eng., 1945-1952 (1919); Bull. Bureau of Standards, 15, 537-571 (1920), (Sci. Paper No. 358).

[3] J. Franklin Inst., Vol. 190, pp. 597-631; 835-870 (1920).

[4] J. Soc. Glass Tech., Vol. VII, pp. 25, 45 (1923).

[5] J. Soc. Glass Tech., Vol. II, pp. 90-120.

[6] Bureau of Standards, Scientific Paper No. 393.

[7] Bureau of Standards, Scientific Paper No. 358.

[8] J. Soc. Glass Tech., 1, 61-73 (1917).

TABLE II

Glass No.	Approximate Percentage Composition SiO_2	Al_2O_3	CaO	Na_2O	Annealing Temperature
1	74.05	0.24	0.21	25.34	483° C
2	73.92	0.20	1.50	23.80	490°
3	74.08	0.21	2.61	23.00	492°
4	74.07	0.28	3.81	21.50	503°
5	73.78	0.38	4.50	20.78	512°
6	73.18	0.58	6.26	19.38	526°
7	74.41	0.30	7.45	17.20	538°
8	74.99	0.31	8.16	16.00	552°
9	74.96	0.42	9.36	14.88	562°
10	74.59	0.45	10.38	14.22	581°
11	74.93	0.38	11.68	13.02	601°

English & Turner, J. S. G. T. Vol. III, pp. 125-128.

The Cooling Process

It has been stated that to anneal glass correctly, the temperature gradient across the section of the glass must be small at those temperatures where the glass enters the "solidification" range, after which the temperature gradient may be progressively increased as the viscosity becomes proportionately greater.

Let us now endeavor to establish a cooling process, taking into account the fact that as the viscosity is doubled for every 8° C. or 9° C. fall in temperature, the temperature gradient, or rate of cooling, may be increased in direct proportion.

The first step in any cooling process must necessarily be the reduction of the temperature gradient across the section of the glass to the smallest limits at the determined annealing temperature, that is, where the glass enters the "solidification" range. It should be made quite clear that it is not sufficient merely to hold the glass at the annealing temperature for a space of two or three minutes, although all existing stresses, provided the whole section of the glass were at the annealing temperature, would be relieved due to the viscous yielding of the glass.

A glass article may require only two or three minutes at its annealing temperature for all existing stresses to be relieved, but the initial distribution of temperature in the ware at the time of manufacture may be such that fifteen minutes would not be too long in which to establish temperature uniformity. A period of 15 minutes in which to remove temperature differences was suggested by Adams and Williamson[3] and for all commercial holloware where the maximum thickness does not exceed 10 millimeters, this seems a very satisfactory period. Following this, the actual cooling treatment can be commenced. A very safe initial rate of cooling would be 1° C. per minute, which means that after eight minutes, the temperature would have fallen 8° C. below the initial annealing temperature. During this temperature drop, the viscosity will have been doubled, or in other words, any stress existing in the glass would require a period twice as long in which to be relieved. The rate of cooling can now be safely double, the next period of 8° C. drop in temperature being at the rate of 2° C. per minute. At the end of the second period, that is 16° C. below the initial annealing temperature, the viscosity is now four times greater than at that temperature, at the end of the third period eight times, and at the end of the fourth period, that is 32° C. below the initial annealing temperature, the viscosity will have been increased by 16 times. If we assume that at the annealing temperature, three minutes would be required to relieve existing stresses, then at a temperature 32° C. lower, as the viscosity is 16 times as great, more than three-quarters of an hour would be required to relieve the same amount of stress.

It is apparent, therefore, that even 32° C below the initial annealing temperature, the glass is beginning to assume the condition where stresses set up due to temperature gradients are of a temporary nature only, being relieved when the temperature differences disappear, say, at ordinary temperatures.

The foregoing example has been arranged below in Table III, the annealing temperature being taken as 550° C.

TABLE III

Time	Temperature	Procedure
O-15 mts.	550° C	Period in which to gain temperature uniformity at the annealing temperature.
23 mts.	592° C	Fall in temperature of 8° C at the rate of 1° C per minute.
27 mts.	534° C	Fall in temperature of 8° C at the rate of 2° C per minute.
29 mts.	526° C	Fall in temperature of 8° C at the rate of 4° C per minute.
30 mts.	518° C	Fall in temperature of 8° C at the rate of 8° C per minute.
30½ mts.	510° C	Fall in temperature of 8° C at the rate of 16° C per minute.

It will be seen from the example given in Table III that at a temperature 50° C. below the annealing temperature, the rate of cooling will have increased beyond the limit possible in any ordinary lehr.

There still appears to be considerable controversy as to the temperature at which rapid cooling can commence. English and Turner[5] after experimental work at Sheffield, came to the conclusion that lime-alkali glasses must be cooled down slowly until 320° C. is reached, the time taken from 550° C. to 320° C. being three and a half hours. Cousens, Howes and Winks,[9] claim that for soda-lime glasses, the temperature interval should be 150° C. before rapid cooling commences and the rate of cooling over this range not more than 4° C. per minute. These figures were criticized by Renn,[10] who stated that in the majority of commercial glasses, the critical range rarely exceeded 50° C. and that rapid cooling could commence with safety 75° C. below the annealing temperature. Adams and Williamson,[3] recommend that after a uniformity period of 15 minutes, the rate of cooling may be 6° C per minute until the temperature has fallen 100° C., after which the rate of cooling may be as high as 20° C. per minute. Coad-Pryor,[11] states that "the values given to the so-called lower critical temperature (which is the temperature at which the glass may be regarded as solid) are, for practical purposes much too low. It is possible to cool bottles rapidly from temperatures exceeding 500° C. without introducing any appreciable amount of strain, provided that the chilling is carried out uniformly and in the absence of draught or local chilling. This means that in a properly designed lehr, it is possible to complete the annealing process in an extraordinary short time."

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[5] J. S. G. T., Vol. XII, pp. 146-158 (1928).
[10] J. S. G. T., Vol. XII, pp. 159-161 (1928).
[11] J. S. G. T., Vol. XI, pp. 30-36 (1927).

Actual practice on modern type lehrs indicates that the short annealing range is quite safe and that rapid cooling can commence when the temperature of the glass has fallen some 50° or 60° C. below the annealing temperature. The shortening of the time taken to pass ware through the lehr is borne out by Meigh[12], who claimed that the complete passage of ware through a Hartford Lehr had been accomplished in 43 minutes.

Stresses in Rapidly Annealed Holloware

The residual stresses in holloware resulting from rapid annealing have been discussed by Zschimmer,[13] who claims that bottles passed through a Hartford Lehr in 80 minutes were not annealed in the ordinary sense of the word, but what was better, they possessed a layer of compression uniformly distributed on the outer surface. The writer maintained that such bottles were "hardened" and not "annealed" in the actual meaning of the word, and "such uniform compression is the alpha and omega of annealing." On the other hand Coad-Pryor,[11] referring to bottles cooled rapidly from temperatures exceeding 500° C., stated that the glass did not show "what one might term a sandwich strain (such as chilled sheet glass shows) when looked at in section."

The obvious questions that arise in dealing with rapidly annealed glass, are how should ware be examined for residual stresses, and what effect have the residual stresses on the strength of the glass?

When a bottle is examined in a strain-viewer in the ordinary way, what is observed is the stress existing parallel to the surface of the glass and invariably one observes what may be termed the resultant of the stresses existing between the bottom and the sides of the bottle. Stresses of this nature are due to one part of the bottle, for example, the bottom, cooling at a rate different from the sides, a zone of extension existing between them. Stresses set up by uniform rapid cooling however, are quite different. In this case the direction of the stress is at right angles to the surface of the glass and is due to the temperature gradient that existed across the wall or section of the glass during cooling. As stresses can only be observed at right angles to their direction, it will therefore be necessary in this case to carry out an observation parallel to the surface of the glass, which can only be accomplished by cutting a section from the bottle. The most efficient manner in which to do this, is to cut a complete section from the body of the bottle, for example, in the case of a cylindrical bottle, a complete ring as shown in Diagram I. Examination of the stress is then carried out inthe direction shown. The sample may either be smoothed with abrasive material and polished or immersed in a bath of liquid whose refractive index is the same or nearly the same as that of the glass. Carbon disulphide, monochlorbenzene, or turpentine are suitable liquids. In this way, the reflections and refractions occurring at the rough portions of the cut ring will be eliminated and an uninterrupted vision obtained completely through the section of the glass.

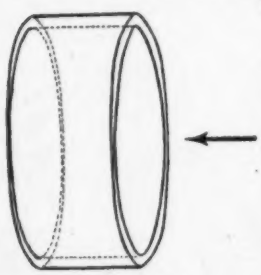


DIAGRAM I

It should be pointed out that in comparing rings, the dimensions regarding length should be approximately the same. When viewed in a strain-viewer fitted with a sensitive selenite plate, a section an inch long will show quite a different set of colors when reduced to half its length, a reduction in length being accompanied by a proportionate decrease in the intensity of the colors seen, due, of course, to the reduction in the amount of stress present.*

Stresses can exist across the section of a bottle to a very considerable extent, while an examination in the ordinary manner in the strain-viewer may show a perfectly annealed bottle. This indicates that the bottle as a whole has been subjected to a perfectly uniform rate of cooling, top, bottom and sides, but owing to the fact that the rate of cooling was rapid, stresses have been set up across the section of the glass which cannot be detected due to their direction, in the ordinary way of examining a bottle, but are only visible when viewed through a section.

Let us now consider how to determine whether these stresses are compressive or tensile. This, of course, is extremely important. If a strip of glass, A, Diagram II, is viewed in the polariscope at an angle of 45° and in the direction indicated by the arrow in the Diagram, and carefully bent as shown in B of the same Diagram, then colored bands at once appear parallel to the surface as shown in the shaded portion of B. If a selenite plate is fitted in the analyzing Nicol of the polariscope, then the colored bands seen will be yellow and blue-green. The colors, of course, intensify with the increased bending of the strip. As the glass strip is actually under mechanical strain while being bent, that is, extended on the upper surface in B of Diagram II, and compressed on the lower surface, it is therefore possible to give definite values to the colored bands. For example, if the lower or compressed surface has a yellow band, then yellow indicates compression, while the blue-green color showing on the upper surface will stand for tension.

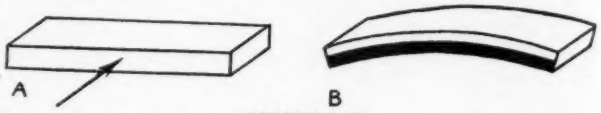


DIAGRAM II

It should be clearly understood, however, that this method of allocating values to the colors appearing in the polariscope applies only under certain conditions. If a further experiment is carried out with the strip illustrated in Diagram II, it will be found that upon rotating the strip through an angle of 90° and again subjecting to careful bending, the surface in compression will now show a blue-green band and the surface in tension a yellow band; in other words the colors for the same stress will have been completely reversed. Care must therefore be taken to ensure that all observations upon "stress-pictures" of this nature are carried out in a similar manner.

[13] J. S. G. T., Vol. XI, p. 37 (1927).
[12] Sprechsaal, 61 (1928), S. 869.

*This is not very well expressed: the stress, as ordinarily understood, and measured in lb./sq. in. is not altered. It is the amount of stressed matter that is decreased, but we think the writer's meaning is clear.—F. W. P.

Electric Glass Annealing Lehrs

By R. M. CHERRY[1]

GLASS, quickly cooled, is in an unstable condition due to stresses acquired in cooling. Glass in this condition is termed "strained." This strained condition may be such that the glass will crack or even fly to pieces when handled or subjected to changes in temperature. When this strained glass is heated to a sufficiently high temperature and then properly cooled, it will lose a large part of its internal stress. This heating and cooling operation used for removing or decreasing the stress in glass is termed annealing.

This annealing operation consists principally of heating the glass article to a uniform temperature, a temperature at which stresses, already set up in the glass when molded, will be relieved quickly, and then uniformly cooling the glass. This means that the cooling portion of the cycle begins with glass without any temperature gradient or stress. Upon cooling, a temperature gradient is established in each piece of glass, this temperature gradient depending upon the thickness of glass, rate of cooling, and method of cooling. The temperature gradient (glass cannot be cooled without temperature gradient within the glass) produces a stress in the glass which is again relieved when the temperature gradient is removed, which may occur at any portion of the cycle as desired or at room temperature.

Whether or not a piece of glass will be without strain after going through the annealing cycle depends upon the temperature gradient (rate of cooling) and the temperature from which the glass is cooled.

Ordinarily, the most critical range for cooling is from the annealing temperature, at which the stresses are relieved, to a temperature of approximately 250° F. below this annealing temperature. After this, more rapid cooling can be used.

It has been definitely determined that the strain in glass can be relieved at a very short time if the correct time-temperature curve can be secured and that a much longer time is required if the correct temperature and time curve is not accurately controlled.

Machine production of glassware demands continuous annealing, and continuous annealing demands an annealing lehr practically trouble-free, flexible, and one in which the time-temperature curve is definitely controlled day-in and day-out, thereby giving uniform anneal and shorter time for annealing.

Electrically heated lehrs provide automatic temperature control and accurate temperature distribution throughout the heating chamber, both in the width and in the length of this heating chamber.

The electric heating units can be located as desired right in the annealing chamber and in each unit the heat can be distributed as desired, such as concentrating more heat near the side of the lehr to take care of the heat losses of the side walls of the lehr. When once the proper temperature distribution is established, both in the width and length of the heating chamber, there will be no change from day to day.

[1]Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.

The correct temperature distribution at all times in a fuel-fired lehr is difficult if not impossible to obtain. While such a lehr may have modern automatic temperature control and be divided into one or more control zones, each control giving a fair uniform temperature record on the control chart, nevertheless the temperature chart represents the temperature at only one point, i.e., the location of thermocouple. In such lehrs, there is no definite relation between the control point and any other point in the zone being heated.

In the electrically heated lehr, there is a definite and constant relation between the control point and any other point in the zone being heated, since the ratio between the amount of heat given up by the electric resistor from any one point and any other point is constant at all times.

This point can easily and accurately be determined by the use of a thermocouple with long leads placed on the conveyor or the glass object being annealed, and temperatures recorded throughout the length of this annealing chamber.

Figure 1 shows temperature curves of a conveyor in a gas fired lehr, one curve giving the temperature of the center of the conveyor and the other curve the temperature of the out-

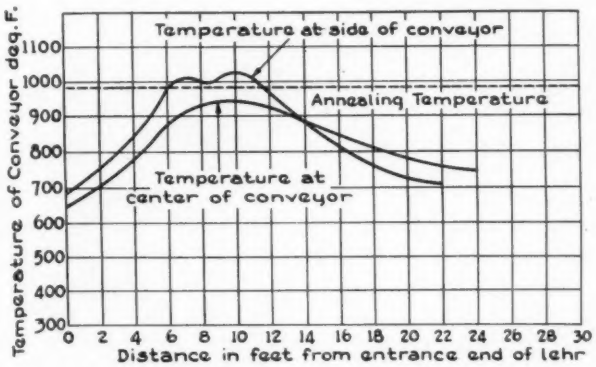


FIG. 1. TEMPERATURE CURVES OF A CONVEYOR IN A FUEL-FIRED LEHR, SHOWING DIFFERENCE BETWEEN CENTER AND SIDE OF CONVEYOR.

side of the conveyor. These curves were taken with a long thermocouple attached to the conveyor so as to accurately read conveyor temperature. During the first portion of the lehr, i.e., the heated section, the temperature at the side of the lehr is considerably higher than the center, while after leaving the heated portion of the lehr, the side temperature gradually decreases until it falls considerably below the center temperature. This is a case where excess heat was provided at the side of the lehr at the heated portion and the decrease in the outside temperature being caused by the cooling effect of the side walls of the lehr beyond the heated portion of the lehr.

Figure 2 shows temperature curves in an electrically heated lehr. The curves in Figure 2 were obtained by means of long leads attached to a thermocouple placed in contact with the glass.

The use of electric heat for glass annealing is probably unquestioned except from the standpoint of cost of operation. The fact that there are a great many electrically heated lehrs in operation annealing various kinds and sizes of ware and located where fuels such as natural gas and oil are available at attractive prices, shows that the electrically heated lehr

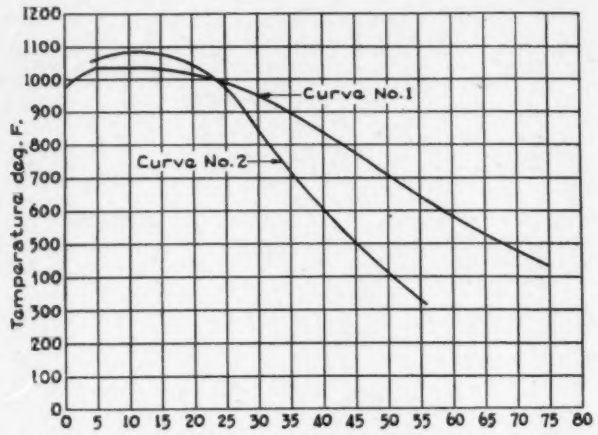


FIG. 2. TEMPERATURE CURVES IN AN ELECTRIC LEHR.

has long passed the so-called experimental stage and is a proven economical application of electricity.

There are several glass plants which are completely equipped with electrically heated lehrs and in most cases the location of these plants is where relatively low price fuels are available. Certainly these complete installations would not have been made if the first lehrs installed had not proven their value economically.

Too frequently, the cost of annealing is determined by estimating or in some cases actually measuring the fuel consumption, in the case of gas or oil, or energy consumption in the case of electric, and multiplying this figure by the unit rate for the source of heat. Occasionally, cost analysis may be made by comparing the theoretical BTU cost between fuel and electric. Any cost comparison of cost of operation based on such cost analysis is very incomplete.

If only the theoretical cost of the BTU available in the fuel is considered, as the basis of selecting the source of heat, then the selection should be soft coal in practically every case. Soft coal is not the fuel commonly used, then certainly there must be something besides BTU cost entering into the cost of annealing.

Every glass manufacturer is interested in producing the highest quality at the lowest over-all cost and under the best possible working conditions.

When over-all cost of annealing is considered, there must be taken into account the effect of the cost of the fuel on the over-all cost, such items for consideration being breakage in the manufacturing plant, breakage after shipment, inspection, cleaning, packing and complaints. Too often this item of complaint is passed over rather lightly as it not only represents a cost of replacing ware broken after shipment but may cause the loss of future business.

The fact that the atmosphere in the electric furnace is always clean and sterile is of considerable importance, as it means that no cleaning is required and the ware may be packed directly from the lehr conveyor. The elimination of subsequent cleaning operations, such as is often required on certain classes of ware, such as prescription ware when annealed in fuel-fired lehrs, may be of more importance insofar as cost is concerned, than the total annealing cost.

The actual energy required for heating a glass annealing lehr is very small for most classes of ware. Such ware as miscellaneous bottles, jars, etc., can be placed in the lehr while the average temperature is considerably above the required annealing temperature. In such cases, the heat required is that to heat the conveyor and supply the losses from the lehr walls less the excess heat contained in the glass.

A lehr equipped with a light woven wire conveyor, such as now used extensively, and properly insulated, becomes almost a heatless proposition. The construction must be such that some heat is required in order to obtain proper temperature control.

In comparing the cost of annealing with electric and fuel-fired heat, the difference on fuel basis only may be in favor of the fuel-fired lehr, but the difference is a fraction of a percent of the total cost of producing the article. A similar fraction of a per cent saving in breakage or any other item affecting the cost of the finished article more than justifies the use of the electrically heated lehr.

The following table gives the actual operating results of five consecutive months in a plant having 13 electric lehrs in operation. It should be borne in mind that these data represent over-all operating conditions which included various types and sizes of ware, varying entering temperature, varying production, heating up after idle periods, etc.

Month	No. 1	No. 2	No. 3	No. 4	No. 5	Average for 5 Mos.
Working days per Month	23	28	23	25	27	25.2
Average No. of Lehrs per day	9	8.6	8	12	13	10.2
Total Lehr days operated per month	207	240	184	300	351	257
KWH per month	80,230	93,690	66,862	115,550	113,230	93,910
KWH per Lehr day	387	390	364	385	322	370
Total tons glass per month					3,800	2,700
Lbs. glass per KWH average.....					67.2	57.5

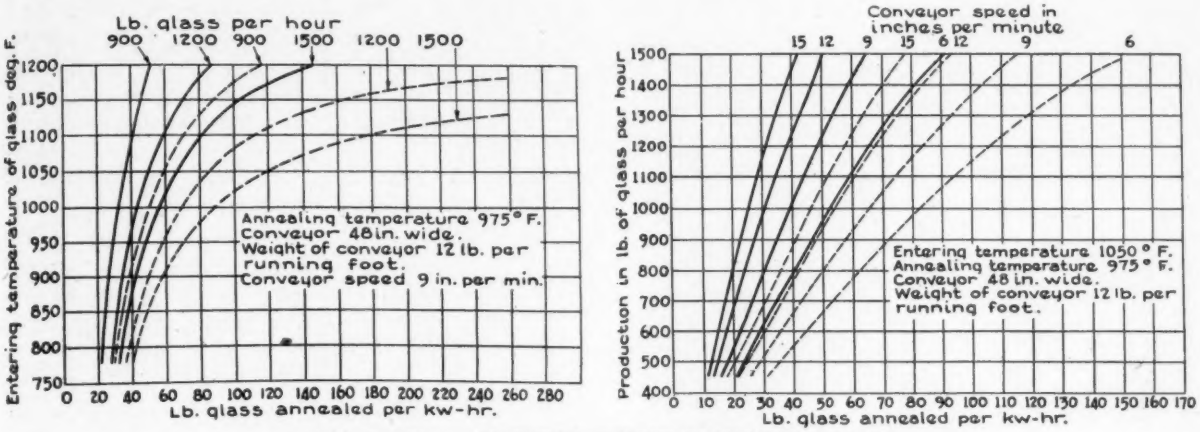
The average economy over the five months' period is given as 57.5 lbs. of glass annealed per KWH. This is equal to 35 KWH per ton, and at 1½ per KWH, a cost of 35c average per ton of glass annealed, certainly a very small percentage of the total cost of producing the ware.

On continuous operation and some classes of ware, economies of operation have been as high as 150 lbs. of glass per KWH in the electric lehr.

Figures 3 and 4 show the effect of entering temperature, production conveyor speed, and preheating of conveyor on the power consumption for a given size lehr. The fact that the pounds of glass annealed per KWH go up very rapidly with the increase in average entering temperature of the glass warrants careful consideration of the design of the entrance of the lehr and the placing of the ware into the lehr at the highest practical temperature.

The electrical equipment required for a lehr consists mainly of the heating units, automatic control panels, and temperature control instruments.

The type of heating unit used is similar to that shown in Figure 5. As will be noted from this figure, the heating unit consists of a heavy metallic resistor wound in short loops so as to eliminate difficulties that would occur from expansion and contraction of the element if long loops were used. The unit is supported and spaced by alundum compound insulators, all of which are mounted in a heat resisting alloy frame.


Lb. glass per hour
900 1200 900 1500 1200 1500
Entering temperature of glass deg. F.
1200 1150 1100 1050 1000 950 900 850 800 750
Annealing temperature 975° F.
Conveyor 48 in. wide.
Weight of conveyor 12 lb. per running foot.
Conveyor speed 9 in. per min.
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280
Lb. glass annealed per kw-hr.
Conveyor speed in inches per minute
15 12 9 15 6 12 9 6
Production in lb. of glass per hour
1500 1400 1300 1200 1100 1000 900 800 700 600 500 400
Entering temperature 1050° F.
Annealing temperature 975° F.
Conveyor 48 in. wide.
Weight of conveyor 12 lb. per running foot.
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
Lb. glass annealed per kw-hr.

FIGS. 3 AND 4. ESTIMATED ENERGY CONSUMPTION OF AN ELECTRIC LEHR FOR VARIOUS PRODUCTION, CONVEYOR SPEEDS AND GLASS ENTERING TEMPERATURE.

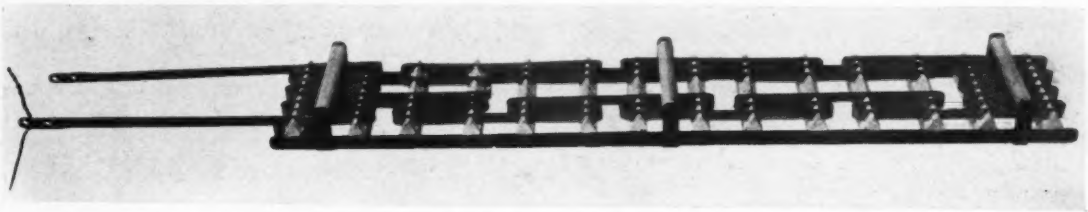


FIG. 5. ELECTRIC HEATING UNIT FOR GLASS LEHRS.

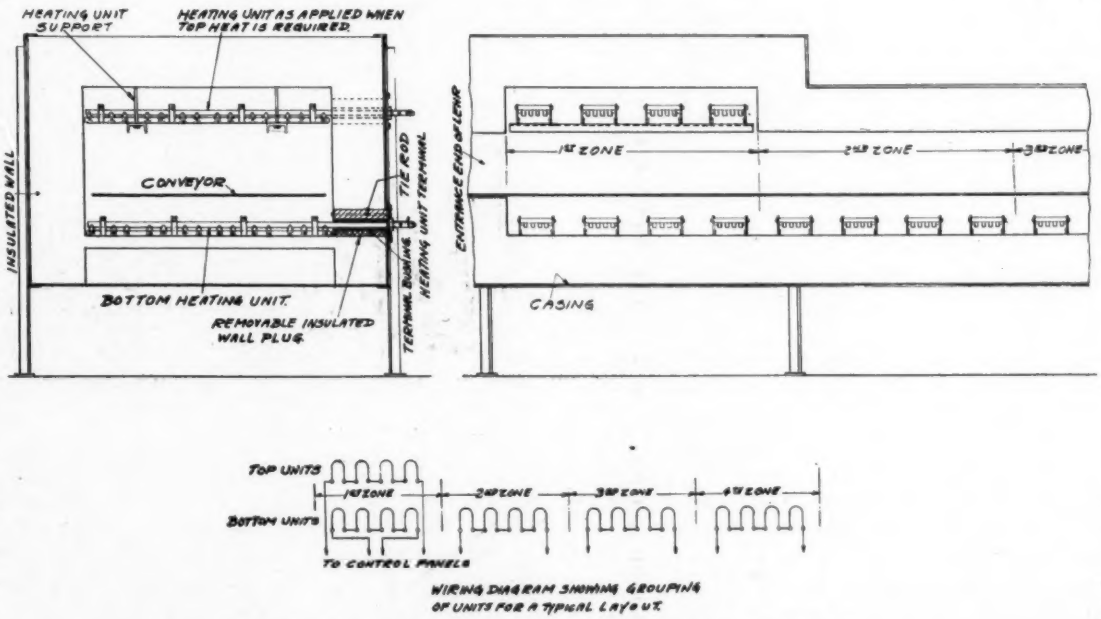


FIG. 6. CROSS-SECTION OF AN ELECTRIC LEHR—SHOWING LOCATION OF HEATING UNITS.

(*Continued on page* 186)

Talking Turkey

THE fourth annual summer meeting of American Glass Technologists was held at Woodmont, Maryland, the week-end of October 8. The Keuka Lake meeting last spring (reported in THE GLASS INDUSTRY for July 1932) had reached the conclusion that the summer meeting, if any, should be held at as central a location as possible, preferably in the Allegheny Mountains half way between Pittsburgh and the coast cities. A questionnaire sent out by the Chairman, Dr. E. W. Tillotson, to a larger circle of members pointed to the same conclusion, and the final location in the panhandle of Maryland met with very general approval.

The Woodmont Rod & Gun Club has a national, and

(Photograph by Donald Sharp)

FIG. 1. MOST OF THEM ARE HERE

almost international, reputation. Founded soon after the Civil War, it has in recent years greatly increased its prestige under the guidance of its present secretary, Henry P. Bridges, a man of much sand. The wild turkey flourisheth here as nowhere else, and the stately deer are nowhere seen to better advantage. Three years ago a new and more commodious club house was built, reputed to be the finest of its kind in the world: it stands, like the former one, on the end of a ridge, one of the foothills of Sideling Mountain, where the ridge breaks off to let the wide Potomac by.

Six thousand acres of game preserve was the week-end playground of the Technologists: and their evenings were spent around great log fires in spacious halls, roofed with joists of the white oak, and plentifully arrayed with horns and heads, front halves, and wholes, of mounted animals, six hundred strong and from the four quarters of the earth. A great elk surveyed the bridge tables where Scholes and Roach and Finn did mighty battle, and a huge bison superintended the gatherings in the main lounge. Panthers and tiger cats crawled everywhere, in unbelievable attitudes, and even snarling, while bears sprawled on every floor and mounted guard, erect, in every corner.

Choice meats there were at every meal, and the flavor of the woodlands was in them. And Henry Bridges carved with evident relish at the one table, and Frank Troutman of the Standard Plate, a governor of the club, at the other. And there was no evidence of depression at either table.

Dr. Tillotson had decided that there should be a minimum of formal program, and gatherings of the whole group were few. But a great number of smaller groups got together and disposed of a great deal of business.

Dr. Howe, of Industrial and Engineering Chemistry, came in with his father-in-law for a brief space, and one group dealt with the problem of organizing a joint meeting of Industrial Chemists and more or less Industrious Technologists.

Dr. Scholes harangued the gathering on the new development at Alfred University, and did it very well, though Donald Sharp tried to divert his attention to the iniquities of the Metric System.

Roy Blunt demonstrated a new method for preventing segregation of batch components at the dog house.

Most of the members took an afternoon off to inspect sand quarries in the neighborhood.

Roy Blunt, J. T. Littleton, C. H. Christie, W. Stevenson and F. E. Troutman decided to go bass fishing on the Potomac, and commandeered two boats for the purpose. The first two fairly flogged the hide off the river for miles of its course, with spinners, plugs, live bait, red plugs, black and white plugs, and flies of all colors; but in the end the only fish caught was caught by Charlie Christie, who doesn't know anything about fishing.

As it was a trifle small, he put it back, and Roy and J. T. noted the spot and went back and caught it again next day.

Some considerable discussion centered around the famous African Woodbuck, whose long-eared and black faced head adorned the walls of the lounge. This animal, Melanocephalus Lignosus, is extremely rare, the head being the only one of its kind in America. It is generally believed that it

(Photograph by Donald Sharp)

FIG. 2. THE POTOMAC IN FRONT OF THE CLUB HOUSE BREAKING THROUGH BETWEEN SIDELING MOUNTAIN AND GREAT CACAPON. MARYLAND THIS SIDE OF RIVER, WEST VIRGINIA, WITH A B. AND O. TRAIN, OVER ACROST.

was shot by the present writer in Africa in 1925, and by him presented to the club. This is Mr. Bridges' version, and it is attested by Jack Waggoner and Tom Sherwood. Some mystery appears to attach to it, however, and it is understood that a detective agency in Baltimore is to investigate the circumstances. So we shall probably hear more of it anon.

F. W. P.

FIG. 3. KIMES, GEER, ROCHE, LYLE, PURDY, SHERWOOD, AND OTHERS.

FIG. 4. FLINT, PURDY, LYLE, TILLOTSON, SHERWOOD, FINN, RIDDLE AND CHRISTIE.

FIG. 5. ARTHUR KIMES, CENTER, EXPLAINS THE MYSTERIES OF GLASS SAND TO DR. TILLOTSON (RIGHT), WHILE ROCHE LOOKS A TRIFLE CYNICAL.

FIG. 6. TILLOTSON AND MORRIS SMITH GO INTO DETAILS.

FIG. 7. HENRY BRIDGES LECTURES AT THE STATUE OF BILLY THE TURKEY DOG.

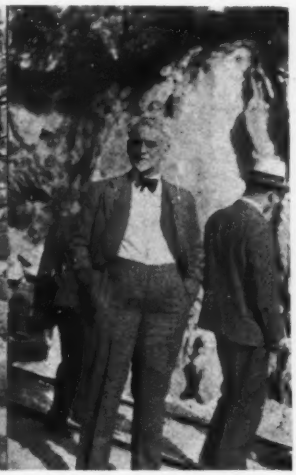


FIG. 8. ROSS PURDY, AS HANDSOME AS EVER.

(All photographs by Jack Waggoner)

List of Those Who Attended the Woodmont Meeting of the Glass Division, A.C.S.

[In order of their arrival, more or less]

Henry P. Bridges, Secretary, Woodmont Rod & Gun Club.
E. Ward Tillotson, Mellon Institute, Pittsburgh, Pa., Chairman of Division.
Jack H. Waggoner, Mellon Institute, Pittsburgh, Pa., Secretary Division.
R. F. Riddle, Pennsylvania Glass Sand Co., Pittsburgh, Pa.
A. W. Kimes, National Glass Budget, Pittsburgh, Pa.
W. F. Curtis, Fostoria Glass Co., Moundsville, W. Va.
Paul E. Geer, Amsler-Morton Co., Pittsburgh, Pa.
Frank W. Preston, Glass Technologist, Butler, Pa.
F. C. Flint, Hazel-Atlas Glass Co., Washington, Pa.
Aaron Lyle, Hazel-Atlas Glass Co., Washington, Pa.
Sam B. Bowman, Hazel-Atlas Glass Co., Zanesville, Ohio.
L. T. Sherwood, Pennsylvania Wire Glass Co., Dunbar, Pa.
Wm. Stevenson, Pennsylvania Wire Glass Co., Dunbar, Pa.
James Bailey, Hamburg, New York.
Sam R. Scholes, Alfred University, Alfred, New York.
L. C. Roche, Maryland Glass Corp., Baltimore, Maryland.
W. R. Lester, Maryland Glass Corp., Baltimore, Maryland.
A. N. Finn, U. S. Bureau of Standards, Washington, D. C.
J. T. Littleton, Corning Glass Works, Corning, N. Y.
Ross C. Purdy, American Ceramic Society, Columbus, Ohio.
H. H. Blau, Macbeth-Evans Glass Co., Charleroi, Pa.
Weston H. Gillett, Macbeth-Evans Glass Co., Charleroi, Pa.
D. O. Evans, Macbeth-Evans Glass Co., Charleroi, Pa.
Frank E. Troutman, Standard Plate Glass Co., Butler, Pa.
C. H. Christie, Standard Plate Glass Co., Butler, Pa.
Royden A. Blunt, Buck Glass Co., Baltimore, Maryland.
Ernest Hommel, The O. Hommel Co., Pittsburgh, Pa.
Donald E. Sharp, Hamburg, New York.
M. A. Smith, McKee Glass Co., Jeannette, Pa.
Geo. V. McCauley, Corning Glass Works, Corning, New York.
H. P. Hood, Corning Glass Works, Corning, New York.
J. W. Romig, Corning Glass Works, Corning, New York.
Geo. W. Morey, Geophysical Laboratory, Washington, D. C.
J. Earle Frazier, Simplex Engineering Co., Washington, Pa.
Harrison E. Howe, American Chemical Society, Mills Bldg., Washington, D. C.
McCulum, Father-in-Law of Mr. Howe.

Instruction for Training Lubrication Engineers

American Society of Mechanical Engineers will shortly have available a complete course of instruction for the training of lubrication engineers. This is being prepared in response to many requests from the industrial world for information on lubricants and bearing testing machines and other special information. The course will deal with fundamentals and with the application of lubricants to all classes of machinery. It will explain the testing of such machinery to determine if the most effective lubricants have been applied in order to indicate the proper corrections for bringing about the highest degree of economy with the lowest possible cost for power and maintenance. The course covers the same fundamentals as used in the training of lubrication engineers for oil companies.

Glass Industry

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Reference to the contents of earlier issues of THE GLASS INDUSTRY can be found in THE INDUSTRIAL ARTS INDEX in many Public and Technical Libraries.

Sensibility to Color Differences

Deals with Colors of Commercial Products

(From Technical News Bulletin No. 186, Bureau of Standards)

There have been many determinations of the number of distinguishable colors in the spectrum. Under the conditions usual in such investigations this number is between 100 and 200. But the observing conditions, with the observer peering into a peephole at a small divided field dimly illuminated are not favorable for detecting small differences in color. Color comparisons dealing with commercial products, on the other hand, are made under much better observing conditions; the observer views fairly large samples with both eyes and is provided with plenty of natural or artificial daylight. Under these conditions it is probable that the number of different colors to be distinguished in the spectrum is more than 1,000.

The colors of the spectrum are the strongest, most saturated colors obtainable, but they are seldom dealt with in the field of commerce. Commercial colors are usually less saturated than spectral colors; they may be matched by some part of the spectrum only when white light is added in the proper proportion, or by mixing two portions of the spectrum together. Adding various proportions of white light produces many thousands of additional distinguishable colors, and variations of these from light to dark raise the total number of distinguishable colors into the millions.

To assist in the specification of the colors of manufactured articles and to develop a method for writing uniform color tolerances, the bureau has been carrying out for a period of years a program of research dealing with fundamental visual psychophysical functions. A valuable contribution to this program is the work of Prof. E. P. T. Tyndall, of the University of Iowa, on the sensibility to wave-length difference as a function of purity, which was conducted by Professor Tyndall, as a research associate of the Munsell Research Laboratory, in the colorimetry section of the Bureau of Standards.

The investigation deals with the colors to be produced by mixing white light with portions of the spectrum; that is, it deals directly with the colors of actual commercial products. The sensibility to wave-length change is investigated as a function of the amount of white light added, enough different wave lengths being chosen throughout the spectrum to permit reliable estimates of sensibility for any part of the spectrum and for any proportion of white light added. This investigation has revealed important new facts and has supplied a large part of the basis required for a method of writing uniform color tolerances.

Standardizing the Inspection of Glass Bulbs

During the past few weeks the four American interests most involved in inspection of glass bulbs have standardized on the retardation plate used for polariscopes. A 565 millimicron plate, 22 mm. in diameter, is to be the standard plate. Those connected with the standardizing of this plate were:

S. McK. Gray, Electrical Testing Laboratories.
J. C. Hostetter, Corning Glass Works.
H. K. Richardson, Westinghouse Lamp Company.
C. D. Spencer, Glass Technology Laboratory, General Electric Company. The above together with Bausch & Lomb Company have already agreed to use the above plate.

Mike Owens as a Human Being

(Continued from the October issue)

Dear Henry:

It is somewhat generally supposed that the first meeting between Mr. Libbey and Mr. Owens was when Mr. Libbey employed Mr. Owens in Wheeling to come to work at his plant in Toledo. This happens not to have been the first meeting between these two, or rather I should express it that this does not happen to be the first time these two came in contact.

In a previous letter, I made reference to William J. Smith, as president of the American Flint Glass Workers' Union. Forty years ago, one of his big tasks was to reconcile and bring to one common level the various wage lists that were, at that time, in use. Also, one of his tasks, to which he applied himself with equal diligence and success, was to bring all the various glass plants in the country within the jurisdiction of his union.

The plan of organization of the union involved an Executive Committee, representative of all the various departments, and the members of this committee were, from time to time, assigned the work of bringing into the union such bodies of workmen as were not yet within the fold, and to cooperate with the president in the work of equalizing the various lists that were then extant. While it was the almost invariable practice of the president to make use of executive officers, on some occasions he selected some member of the organization who did not have an official capacity but who seemed to have the energy and willingness to bring about a result desired.

Mr. Libbey was operating a plant with waning success at Sandwich, Mass., and that plant was a thorn in the flesh to those workmen in the Ohio Valley whose product came in competition with that of the workmen employed by Mr. Libbey.

Mr. Libbey was having great difficulty in keeping his plant in operation, feeling the competition of the Ohio Valley plants.

The union selected a committee of Ohio Valley workers to go to Sandwich, Mass., where the men were either on strike at the time or contemplating a strike, and encourage them in their demands to the extent of striking or prolonging the strike.

The head of that committee that went from the Ohio Valley to Sandwich, was our friend Mr. Owens. Mr. Owens and his committee were successful to the extent of having the men lay down their tools and quit work, and those who were already out to have them determine themselves to a continuation of the strike, but the outcome of it was that Mr. Libbey notified the men that unless they would resume their places and continue to work as formerly, he would close the plant down permanently, notwithstanding all the denials of the walking delegates from the union. This he did, and later moved to Toledo, Ohio.

Little did either of these two think, at that time, that they, each on opposite sides of that bitter controversy, would some day come together and revolutionize an industry.

Yours very truly,

Dear Henry:

Forty years ago, the Ohio Valley, centering around Wheeling, produced probably a greater variety of fine glassware than any other territory in the country. Wheeling was the center of a very highly skilled glass working fraternity.

The question is often asked, "What class of workman was Michael J. Owens?" I will first say that Mike was a fine workman, generally recognized as such by his fellows and by whomsoever he was employed.

Lamp shades in both opal and flint glass were made in two manners. One was to blow them in a paste mold and then by cutting away a part and grinding, the completed shade resulted. Mike, for a period, did this work, at which he was quite skilled. Opal glass has a distinctly different character from flint glass, inasmuch as it gives up its heat very much more rapidly. One might be a skilled workman handling flint glass, and be quite indifferent handling opal, because of its different nature, but Mike was a fine workman whether handling flint or opal glass.

Another method of making lamp shades was known as the off-hand. In this process a gatherer would gather on the end of the blow pipe the required quantity of glass, which for shades was quite considerable. After a preliminary working and shaping of the glass on what was known as the marver (hand) plate, the pipe with its attached glass, partly worked, was handed to the blower, who with the use of tools and a glory hole for reheating gave to the article its final shaping. This was quite a skilled work, and as the pipe with its attached glass was quite heavy it was likewise laborious. The article had to be kept within very definite limits, as to diameter and as to shape. Mike's later work was as a blower of off-hand lamp shades.

It is a curious fact that Mike had no experience whatever in the line of glass manufacture where his great successes ensued.

He was not a chimney maker and yet one of his first inventions was a method of producing paste mold lamp chimneys eliminating the blower. His great success was in bottles, in connection with which he had very little experience prior to his inventions. As a matter of fact, he knew but little about the hand blown art of producing bottles, and only took up a study of the then developing machines or improved tools that were coming into use about the time he undertook his epochal experiments.

It is to be noted that almost everything, except possibly the revolving pot of the furnace, that was vital to the development of the machine had been anticipated by others. Arbogast anticipated the pre-forming of a blank, Proeger vacuum as a means of getting glass into the mold, John J, Powers, of Pittsburgh, certain mechanical movements that were essential; in fact it was Mike's great vision that made his success possible. Others had foreseen the possibilities of doing certain things, but lacked the vision to make their dreams effective.

Yours very truly,

Dear Henry:

Prior to the machine era in bottle making, the problem of child labor was an intense one, both with respect to the operators of bottle factories, and the general public.

There was a time when no law limited the employment of children, and their employment depended almost wholly upon the need or cupidity of parents. All the factory managements employed these children, not entirely because they were low waged, but largely because, being young and nimble and quickness being an important element in their work, they were more to be desired at the kind of work they did than were adults.

The shop system, which was universal in bottle making, generally consisted of three blowers and from four to six boys. These were known as cleaning off boys, mold boys, sticking up boys and carrying in boys.

Gradually laws began to be enacted and in a measure enforced, first limiting the age to eleven years, which gradually crept up to fourteen years in most states, and in some states even higher.

In the state of Pennsylvania, I had considerable experience, from a legislative standpoint, with this problem. From 1904 to 1910, I was chairman of the Glass Manufacturers of Pennsylvania, which was organized to look after legislative matters affecting particularly the employment of minors in factories. The legislature in Pennsylvania meets each two years and during three of its sessions I spent considerable time at Harrisburg. I was thrown in pretty close contact with Mr. Lovejoy of the National Child Labor League, and with officers of other similar organizations. In 1906 I made the suggestion to Mr. Lovejoy of my own volition, to raise the minimum age from twelve to fourteen years, which was enacted and became a law, and is still the law in Pennsylvania.

The enforcement of the law in Pennsylvania, as it was in other states, was difficult. While there were factory inspectors who would come to the factory quite frequently, many devices were employed to evade the law. I find it hard to criticize factory managements in this regard, because the minor help in the factory determined, very largely, whether it would work or not. There was never an abundance of small help, and the day that some shops were not idle because of the shortage of small help was unusual.

While I always recognized the evil of having small children work in the factory, and while this system was ugly at its best, there was a certain picturesqueness that still adheres to my memery of it. I can remember these little fellows gathering in the factories of a morning about six-thirty, lugging dinner pails almost

as large as themselves in some instances; and then the rattle of pans and irons as these little fellows prepared themselves for the day's work; and then the constant grind from that until five-thirty of the evening, with an hour's intermission for dinner, and the so-called temp periods at ten o'clock and at three o'clock for lunch. I can see these little fellows standing up to the daily task with the same fortitude as their elders.

I have given this somewhat incomplete picture of the child labor element in bottle making in the early days, in order that you might properly appreciate a factor growing out of Mr. Owens' inventions that has been very much lost sight of.

Notwithstanding all the legislative enactments, the efforts of the National Child Labor League and of other bodies that interested themselves in the subject of child labor, it still endured as a problem for which no final solution had been found until the machine came into the industry. The machines other than those of Mr. Owens were only a partial solution, as they only reduced the number of boys required, but the machine of Mr. Owens eliminated entirely child labor from bottle making.

Figuratively speaking, the invention of Mr. Owens overnight did, in the great cause of child labor, that which all the legislative and other efforts had failed to do.

Yours very truly,

Electric Glass Annealing Lehrs

(*Continued from page* 181)

This makes a very compact, rugged type unit, one which is easily installed or removed. As will be noted in this figure, extra heat is provided at the end of each unit which concentrates extra heat at the edges of the lehr conveyor, thereby giving correct temperature distribution across the width of the lehr.

In Figure 6 is shown the location and mounting of the heating units in the heating chamber and the insulated wall plug which fills the opening through which the heating unit is inserted or removed. As a rule, top units are used only in the first zone, and in many cases, the top heating units in the first zone will not be required. The bottom heating elements are mounted underneath the conveyor and may be placed directly on the floor of the lehr in case the conveyor returns outside the lehr or supported above the floor of the lehr, in case the conveyor returns inside of the lehr.

For a typical "jitney" type lehr, from 12 to 20 heating units may be used, each unit being an independent unit readily removable through a side wall of the lehr. These units are grouped into three or four independently controlled circuits or zones.

By having the heating units readily removable, this permits repair or replacement in case of accident without seriously affecting the production, since the units may be replaced while the lehr is in operation.

The heating element used is a standard nickel-chromium alloy as used for high temperature furnace work and will give almost indefinite life at annealing lehr temperature. As stated, the heating unit frames are made of heat resisting alloy, thereby eliminating deterioration of these frames by oxidation.

With electrically heated lehrs, the heat is all distributed along the heating chamber, divided into zones, as described above, so any temperature characteristic can be secured and automatically maintained. Furthermore, the temperature characteristics can be readily changed for different kinds or sizes of ware by adjustment of the instrument setting. This, together with the variable speed adjustment on the conveyor drive, makes possible complete control of the annealing cycle.

The electric lehr provides an automatically controlled device and if full advantage is taken of this, the highest quality at the lowest over-all cost and under the best working conditions can be obtained.

Owens-Illinois Acquires Root Glass Company

Net earnings of Owens-Illinois Glass Company and its subsidiaries for the twelve months' period ended September 30, 1932, were $2,030,573.49. In arriving at these earnings, deductions have been made for interest on all outstanding securities, depreciation, depletion, repairs, Federal Taxes, bad accounts and contingencies. Depreciation and depletion have been charged against both operating and non-operating plants at the same rate as used in prior periods. These earnings are equivalent, after providing for dividends on preferred stock, to $1.68 per share on the 922,173 common shares outstanding as compared with $1.46 per share for the twelve months' period ended June 30, 1932, and $2.51 per share for the twelve months' period ended September 30, 1931, during which periods the same number of shares were outstanding.

The Company's cash and net working capital have been increased As of September 30, 1932, total current assets were $18,493,936.91, of which $4,779,284.98 was in cash and short time U. S. Government securities and $876,104.16 was in other marketable securities having a market value on September 30th of $972,050. Total current liabilities were $2,076,621.72, including $701,086.50 provided for the dividends payable November 15, 1932, on the common shares and January 1, 1933, on the preferred shares, making a net working capital of $16,417,315.19. The following items were not considered as current in arriving at the net working capital figure:

Cash surrender Value of Life Insurance	$845,169.37
Cash in Closed Banks, less Reserve	384,629.51
Mutual Insurance, Deposits	162,552.34

Manufacturing costs have continued to decline and inventories of finished products, raw materials and supplies of $8,968,021.26 were the lowest in the history of the present Company's operation.

President William E. Levis announced also that Owens-Illinois Glass Company has applied to the New York Stock Exchange for permission to list 55,000 shares of its $25.00 par value Common stock, which is to be issued in connection with the purchase of all the assets and business of Root Glass Company of Terre Haute, Indiana. The contract for the purchase of the assets of the Root Glass Company has been approved by the Boards of Directors of both companies.

The Root Glass Company has three furnaces in its Terre Haute, Indiana, plant and has enjoyed a favorable reputation in the glass industry for more than thirty years. It was largely specialized in the manufacture of beverage bottles, although it also manufactures other types of glass containers. The customers of Owens-Illinois Glass Company, located in the district adjacent to Terre Haute, will obtain the advantage of the added facilities of Root Glass Company and all its customers in the beverage bottle field are expected to benefit by the high standard of quality and service, upon which the reputation of the Root Glass Company has been built.

C. J. Root, founder and president of Root Glass Company, will become a director of Owens-Illinois Glass Company and will remain actively identified with the business.

Organize to Modernize Industrial Plants

In connection with the coming Power and Mechanical Engineering Exposition, announcement was made that the National Committee on the Modernization of Industrial Plant Facilities, under the chairmanship of A. W. Robertson of Pittsburgh, was formed at a conference of the President with representatives of bank and industrial groups from the 12 Federal Reserve districts. The committee plans an intensive drive to rehabilitate industrial equipment throughout the industry. It is stated that "fifty percent of the machinery, equipment and plant facilities in American factories is obsolete, viewed from the fact that in the last three years there has been more improvement in equipment design than in any like period of our industrial history, and that replacement has not kept pace with engineering advance." And furthermore, "that many corporations having liquid funds drawing low interest might better invest at this time in more profitable equipment."

February Meeting of American Ceramic Society

The tentative program outlined for the annual meeting of the American Ceramic Society during the week of February 12, 1933, at the Hotel William Penn, Pittsburg, Pa. has been announced as follows:

Sunday, February 12, Meeting of Board of Trustees, 8 p. m. Reception in the Silver Room, 8:30 p. m. Entertainment in the Urban Room.

Monday, February 13, 10 a. m. General meeting Urban Room, 12 m. General luncheon for all members of the Society, 2 p. m. Division meetings, 8:30 p. m. Frolic and dance, major ballroom under auspices of the Materials and Equipment Division.

Tuesday, February 14, 9:30 a. m. Division meetings, 12 m. Division luncheons, 2 p. m. Division meetings, 8 p. m. Public lecture by Dr. A. L. Day under the auspices of the Fellows.

Wednesday, February 15. 9:30 a. m. Division meetings, 12 m. Division luncheons, 2 p. m. "see Pittsburgh tour," 8 p. m. theatrical performance Little Theatre, Carnegie Institute of Technology.

Thursday, February 16. 10 a. m. General business meeting, induction of officers, 12 m. General luncheon, 2 p. m. Meeting on business management, 6 p. m. dinners for special groups.

Friday, February 17. Plant visits.

Small Gain in August Contracts

August contracts for new construction of all descriptions awarded in the 37 states east of the Rocky Mountains showed a gain of 4 per cent over July awards according to F. W. Dodge Corporation. The August figure of $133,988,100 compares with $128,768,700 for July and $233,106,100 for August, 1931. Gains over July were shown in building, both residential and non-residential, as well as in engineering works. The contract total for engineering works was only 12 per cent smaller than the total shown for this class of construction during August, 1931.

Plate Glass Production Shows Good Gains

The total production of polished plate glass as reported by P. A. Hughes, secretary of the Plate Glass Manufacturers of America, for the month of September, 1932, was 3,405,854 sq. ft., as compared to 1,773,470 sq. ft. produced by the same companies in the preceding month, August, 1932, and 4,610,930 sq. ft. produced by the Association members in the corresponding month last year, September, 1931.

This makes a total of 37,204,792 sq. ft. produced by these companies during the first nine months of 1932.

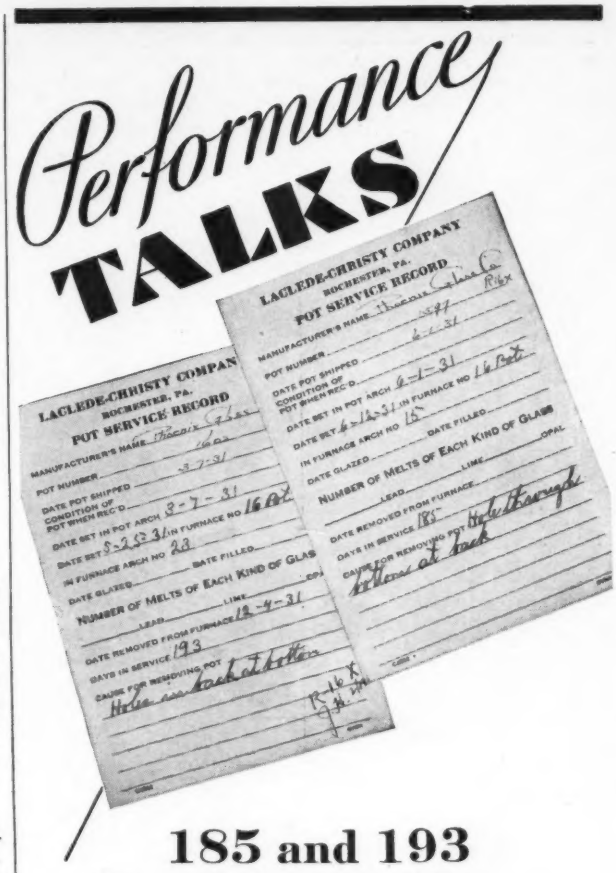
Statement of the Ownership, Management, Circulation, etc., required by the Act of Congress of August 24, 1912, of THE GLASS INDUSTRY, published monthly at New York, N. Y., for October 1, 1932, State of New York, County of New York—ss. Before me, a Notary Public, in and for the State and County aforesaid, personally appeared G. W. Cooper, who, having been duly sworn according to law, deposes and says that he is the managing editor of THE GLASS INDUSTRY, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Glass Industry Publishing Co., Inc., 2 Duane St., New York; editors, none; managing editor, G. W. Cooper, 2 Duane St., New York; business manager, G. W. Cooper, 2 Duane St., New York.

2. That the owners are (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock): Glass Industry Publishing Co., Inc., 2 Duane St., New York; G. W. Cooper, 2 Duane St., New York; R. D. Proctor, 2 Duane St., New York.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are (If there are none, so state): None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting is given; also that the said two paragraphs contain statements, embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him. G. W. COOPER, Managing Editor. Sworn to and subscribed before me this 22nd day of September, 1932. [Seal] ELISE P. O'CONNOR, Notary Public. (My commission expires March 30, 1934.)



185 and 193 Day Runs for These 2 L-C Pots

Laclede-Christy Pots certainly do stand up! The illustration above shows that. It is an actual photograph of two of our "pot service record cards," which we furnish to every customer.

Whether *you* get 193 day runs from the Laclede-Christy Pots *you* buy—or better, or worse—depends largely upon your individual plant conditions and practices. But rest assured that whatever these conditions are, Laclede-Christy Pots will give you the very *maximum* of service and performance.

Let your next pots be "Laclede-Christy."

LACLEDE-CHRISTY, ST. LOUIS, U. S. A.

P-4

LACLEDE-CHRISTY POTS

Current Prices of Glass-Making Materials

October 21, 1932

Quotations furnished by various producers, manufacturers and dealers.

Acid		Carlots	Less Carlots
Citric (dom.)	lb.	..	.29
Hydrochloric (HCl) 20° tanks, per 100 lb		..	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb	..	.13½
52% and 48%	lb	.10	.10-.11½
Nitric (HNO_3) 38° carboy ext. Per 100 lb		5.50	..
Sulphuric (H_2SO_4) 66° tank cars	ton	5.50	..
Tartaric	lb	..	.23½
Alcohol, denatured	gal.	..	..
Aluminum hydrate (Al $(OH)_3$)	lb	.04½-.05	.05½-.06
Aluminum oxide (Al_2O_3)	lb	..	.07
Ammonium bifluoride (NH_4) FHF	lb	..	.15½
Ammonia water (NH_4OH) 26° drums	lb	..	..
Antimony, metallic (Sb)	lb	.02½	.02¾
Antimony oxide (Sb_2O_3)	lb	..	.09¾
Antimony sulphide (Sb_2S_3)	lb	..	.08½
Arsenic trioxide (As_2O_3) (dense white), 99%	lb	.. .04	.14 .04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	47.00	..
90% through 100 mesh	ton	44.00	..
Barium hydrate ($Ba(OH)_2$)	lb.	..	.05¼
Barium mixture, glassmaker's, f.o.b. St. Louis	ton	25.00	..
Barium nitrate ($Ba(NO_3)_2$)	lb.	..	.07¼
Barium selenite ($BaSeO_3$)	lb.	..	..
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk, f.o.b. shipping point	ton	15.00-16.00	18.00
Bone ash	carlots, lb	.06	.06½
Borax ($Na_2B_4O_7.10H_2O$)	lb	..	.02¼-.02¾
Granulated	In bags, lb.	.02	.02½-.02¾
Powdered	In bags, lb.	.02¼	..
Boric acid (H_3BO_3)	In bags, lb.	.04¼	..
Cadmium sulphide (CdS)—			
Red	lb	..	.65-.90
Orange	lb.	..	.60-1.10
Yellow	lb		1.30-1.50
Chromium oxide (Cr_2O_3)	lb	.18½	.19
Cobalt oxide (Co_3O_4)			
In bbls.	lb	..	1.25-1.45
In 10 lb. tins	lb	..	1.35
Copper oxide			
Red (Cu_2O)	lb	..	.25
Black (CuO)	lb	..	.17-.19
Black prepared	lb	..	.22
Cryolite ($Na_3Al\ F_6$) Natural Greenland Kryolith)	lb	.09	.09¼
Synthetic (Artificial)	lb	..	.09½
Epsom salts ($MgSO_4$) (imported) Per 100 lb		..	1.15-1.20
*Feldspar—			
100 mesh	ton	11.50-17.50	12.00-18.00
80 mesh	ton	11.00-11.50	13.00
40 mesh	ton	10.75-11.00	12.00
20 mesh	ton	9.50-11.00	..
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f.o.b. mines	ton	30.00	..
In bags or barrels	ton	34.00	39.00
Imported	ton	30.00-31.00	33.00-37.00
Formaldehyde	lb	..	.07
Graphite (C)	lb	..	.04-.07
Iron oxide—			
Red (Fe_2O_3)	lb	..	.0425
Black (FeO)	lb	.04½	..
Kaolin (f.o.b. mine)	ton	8.00-9.00	..
English, lump, f.o.b. New York	ton	14.50-25.00	24.50-30.00

*Spot Shipments.

Kryolith (see Cryolite)		Carlots	Less Carlots
Lead chromate ($PbCrO_4$)	lb	..	.30
Lead oxide (Pb_3O_4) (red lead)	lb	.050	.06¾
Litharge (PbO)	lb	.045	.05¾
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	5.50	..
Burnt (CaO) ground, in bulk	ton	5.00	..
Burnt, ground, in paper sacks	ton	7.00	..
Burnt, ground, in 280 lb. bbls.	Per bbl	2.15	..
Limestone ($CaCO_3$)		1.50-2.50	..
Magnesia (MgO)—			
Calcined, heavy (in bbls.)	lb	.06	.07
light (in bbls.)	lb	..	.23
extra light (in bbls.)	lb.	..	.37
Magnesium carbonate ($MgCO_3$)	lb	.06	.10
Manganese 85% (MnO_2)	lb	.03	.03
Nickel oxide (Ni_2O_3), black— for nickel content	lb	..	.35
Nickel monoxide (NiO), green— for nickel content	lb	..	.35
Plaster of Paris, bags	ton	$1.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb	.09	.09¼
Ground	lb	11	.12
Potassium carbonate—94-96%	lb.	.0555	.0555
Calcined (K_2CO_3) 96-98%	lb	.06¼	.07
Hydrated 80-85%	lb.	.05¾	.06¼
Potassium chromate (K_2CrO_4)	lb.	..	.25
Potassium hydrate (KOH) (caustic potash)	lb	.07½	.08
Potassium nitrate (KNO_3) (gran.)	lb	..	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb	.16½	.17½
Powdered blue	lb.	..	1.35
Rochelle salts, bbls.	lb.	..	.13½
Rouge	lb.	..	..
Rutile (TiO_2) powdered, 95%	lb	.15-.20	.20-.25
Salt cake, glassmakers (Na_2SO_4)	ton	22.00	..
Selenium (Se)	lb	..	1.70
Silver nitrate (AgNO.) (100 oz.)	per oz	..	.20¼-.20¾
Soda ash (Na_2CO_3) dense, 58%—			
Bulk, on contract	Flat per 100 lb	1.05	..
In barrels	Per 100 lb	1.38	1.90-2.13
In bags	Per 100 lb	1.17½	1.72½-1.92½
Spot orders .025 per 100 lbs. higher		..	..
Sodium bichromate ($Na_2Cr_2O_7$)	lb	.07	.07½
Sodium hydrate (NaOH) (caustic soda) Solid	Per 100 lt	2.50	..
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	lb	..	3.62
95 per cent.	Per 100 lb	1.145-1.245	1.195-1.295
Sodium selenite (Na_2SeO_3)	lb		2.00
Sodium fluosilicate (Na_2SiF_6)	lb.	.05½	.06
Sodium uranate (Na_2UO_4) Yellow or Orange	lb	..	1.50-1.55
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb	3.45	3.80-4.00
Flowers, in bags	Per 100 lb	3.10	3.45-3.65
Flour, heavy in bbls.	Per 100 lb	2.85	3.20-3.40
Tin chloride ($SnCl_2$) (crystals)	lb	.37½	.39
Tin oxide (SnO_2) in bbls.	lb	.28	.29½
Uranium oxide (UO_3) (black, 96% U_3O_8) 100 lb. lots. Black	lb	..	2.75
Yellow	lb	..	1.50
Zinc oxide (ZnO)	lb	.08½	.12
American process. Bags	lb	.05¾	.06
Zircon			
Granular (Milled .005-.02c higher)		.07	.07½-.08
Crude. Gran. (Milled .005-.02c higher		.03½	.04-.05

Monthly Summary of United States Foreign Commerce in Glass

EXPORTS Corrected to Sept. 22, 1932	August 1931 Quantity	August 1931 Value	August 1932 Quantity	August 1932 Value	Eight Months Ending August 1931 Quantity	Eight Months Ending August 1931 Value	Eight Months Ending August 1932 Quantity	Eight Months Ending August 1932 Value
Glass and glass products (Total)	.....	$470,297	.....	$263,064	.....	$4,973,984	.....	$2,822,079
Plate and window glass—								
Window glass, common, box 50 sq. ft	1,267	4,736	275	1,539	5,979	29,690	1,246	7,630
Plate glass, unsilvered, sq. ft	204,200	63,839	100,753	29,672	2,722,175	830,699	2,027,945	571,668
Other window and plate glass	lb. 186,922	15,854	25,691	3,106	2,016,781	209,840	752,515	92,625
Glass containers (bottles, vials and jars)	.....	181,739	.....	83,376	.....	1,426,958	.....	763,157
Table glassware, plain	.....	60,387	.....	25,771	.....	611,681	.....	341,470
Table and other glassware, cut or engraved	.....	4,817	.....	1,311	.....	58,041	.....	27,173
Lamp chimneys and lantern globes	lb.	4,392	.....	2,581	.....	66,613	.....	41,074
Globes and shades for lighting fixtures	lb.	23,631	.....	14,361	.....	283,771	.....	147,041
Chemical glassware	lb. 11,168	8,993	12,010	11,865	101,576	99,919	74,969	69,955
Electrical glassware, except for lighting	lb. 80,915	5,278	52,337	5,293	1,091,838	71,138	622,616	728,437
Other glassware	.....	96,631	.....	84,189	.....	1,222,634	.....	31,849
IMPORTS **Corrected to Sept. 22, 1932**								
Glass and glass products	.....	$537,842	.....	$295,963	.....	$4,941,089	.....	$2,143,327
Cylinder, crown, and sheet—								
Plain	dut. lb. 923,820	38,207	441,498	14,545	6,037,679	234,562	2,319,333	459,549
Bent, beveled, colored, etc	dut. lb. 128,951	19,997	17,388	3,002	1,282,106	174,322	906,938	1,821,220
Plate glass	dut. sq. ft. 283,335	47,364	60,501	13,744	3,415,309	868,053	3,548	3,164
Glass mirrors	97	359	114	225	1,050	2,758	.....	49,157
Rolled, cylinder, crown, and sheet glass, ground, obscured, bent, beveled, colored, etc	.....	6,591	.....	2,027	.....	52,732	.....	3,266
Laminated glass and manufactures, and plated glass	.....	601	.....	75	.....	15,802	.....	225,447
Bottles, vials, jars, and other containers	.....	45,207	.....	41,874	.....	235,977	.....	196,722
Scientific articles and utensils	dut.	46,675	.....	27,983	.....	274,868	.....	46,875
Tubes and rods	dut.	17,889	.....	5,244	.....	91,525	.....	133,701
Illuminating articles	dut.	29,328	.....	19,490	.....	246,558	8,441,095	68,076
Blown glass articles—								
Bulbs for electric lamps, without filament	dut. 945,642	8,388	1,116,836	7,901	9,091,010	85,693	.....	602,608
Other blown glass articles	dut.	187,228	.....	102,863	.....	984,303	.....	68,477
Pressed glass articles	.....	11,308	.....	7,228	.....	80,143	.....	397,173
Other glassware	.....	78,700	.....	49,762	.....	583,793	.....	.....